Is Mallampati scoring and PPNC an easier and better predictor for Obstructive Sleep Apnea (OSA)?

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Abstract

Background: Obstructive sleep apnea is a spectrum of sleep disturbances that cause short term and long-term effects including development of Type II diabetes mellitus, metabolic syndrome, hypertension and coronary artery disease. Mallampati score (MP) and percent predicted neck circumference (PPNC) together is considered to predict obstructive sleep apnea. The objective of the study is to assess the validity of PPNC and MP in the prediction of OSA.

Material and methods: The study was a cross sectional study conducted among software professionals belong to Information Technology (IT) firms of Chennai. A total of 71 participants were included. All study participants were screened with berlin questionnaire and assessed with modified Mallampati scoring and overnight type IV polysomnography. PPNC was calculated. Predictive ability was assessed with ROC curve analysis, sensitivity, specificity, positive predictive value and negative predictive value.

Results: Among the study participants, 86% were males and 14% were females. 21% belong to normal BMI. Mean(SD) of BMI, Neck circumference and PPNC was 26.2 (+3.77), 37.97(+3.48) and 94.23 (+8.17) respectively. AUC for PPNC was 0.59(0.46-0.72); Sensitivity of PPNC was 70% and specificity 48.78%, positive predictive value of 50% and negative predictive value of 68.97%. AUC for Mallampati Score was 0.57(0.44-0.71). Sensitivity of MMS in prediction of OSA was 40% and specificity 75.61% with a positive predictive value of 54.55% and negative predictive value of 63.27%. AUC for MMS and PPNC together was 0.843 (0.738-0.949), which was good enough. (p value=0.000); sensitivity of MMS and PPNC in prediction of OSA was 90% and specificity 77.77% with a positive predictive value of 86.95% and negative predictive value of 84%.

Conclusion: Though individually MMS and PPNC have fair predictive ability, their combined predictive ability is much higher.

Keywords: Obstructive Sleep Apnea, Mallampati scoring, PPNC

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Introduction: Obstructive sleep apnea is a spectrum of sleep disturbances that cause short term and long-term effects to human body. Short term effects including excessive daytime sleepiness, poor cognition, inability to concentrate and high risk of road traffic accidents. Whereas long term is concerned, several studies have shown over and over again about the development of Type II diabetes mellitus (1), metabolic syndrome, hypertension and coronary artery disease. OSA is known to cause obesity due to the high levels of Insulin being secreted due to poor sleep quality and quantity. Obesity in turn worsens OSA due to increase in all the vital statistics of human body. Incidence of OSA is distributed across all ages which is alarmingly increasing. Incidence of OSA in pediatric population is 1-3%(2), whereas in adults it is approximately 9% to 38% across various ethnicities and countries(3). One of the studies in India shows an overall incidence of 9.3%, 13.5% in males, 5.6% in females(4). Another study in India reported an incidence of 4.4% in males and 2.5% in females(5). Prevalence of OSA was found to be 19.5 per cent in a study from West India (6). Even though there is a high incidence of OSA, Indians are least bothered about OSA as other major problems like Tuberculosis and epidemic viral fevers keep the health system of this country always busy. Another cause of high incidence is due to the ignorance of the disease state itself. The gold standard of diagnosis being overnight polysomnography which is expensive and time consuming makes it even more unreachable. According to the 2011 census of India, 68.84% of Indians (around 833.1 million people) live in 640,867 different villages, where overnight polysomnography, X ray, MRI and even cephalometric measurements are not possible to diagnose OSA. Mallampati scoring means categorizing the subjects by visualization of the oropharynx. It is non-invasive and economical, very simple and does not require any special equipment or setting. Normally it is used in Anaesthesia to assess the airways before intubation procedure. The American Academy of Sleep Medicine suggest the presence of OSA include increased neck circumference (>17 inches in men, > 16 inches in women), body mass index (BMI) ≥ 30 kg/m², a Modified Mallampati score of 3 or 4 (7). One of the meta-analysis data from Netherlands shows no evidence to maintain that the Mallampati score is of added value for ruling in or ruling out a diagnosis of OSA in patients suspected for OSA (8). The imbalance in the anatomical structures inside the mouth leads to the pathogenesis of OSA which is been already proven (9) and hints more in favour of Mallampati scoring. When compared to Caucasians, OSA among Chinese and Asian is more due to the craniofacial and oropharyngeal abnormalities in bony structure(10). Oropharyngeal patency, tongue size and Mallampati scoring are researched to be associated more with OSA severity (11). PPNC (percent predicted neck circumference) using the formula: PPNC = (1000 x NC)/ ([0.55 x H] + 310) is a better predictor(12) for OSA as height also is taken into account. Neck circumference and PPNC was positively associated with high risk for OSA(13). PPNC accurately predicts the high-risk category of OSA(14). However, there is sparse literature which utilizes Modified Mallampati scoring (MMS) and PPNC in the prediction of OSA. Both of the assessment methods can be used as a first hand screening tool for rural India. Though multiple parameters are there to predict OSA, simple measures and their predictive values are not evaluated and hence this study was initiated. The objective of the study is to assess the predictive ability of PPNC and MMS in prediction of OSA.

Material and methods
The study was a cross sectional study. The study participants were from Chennai. The site where the study included was a software company which has around 300 employees. All study participants were screened for OSA with Berlin questionnaire(15). Male participants in the age group of 22-60 years who completed the questionnaire were included in the study. Participants with comorbid conditions such as known any respiratory illness and congestive cardiac failure were excluded.

Sample size was calculated with Buerders’ formula(16). Z: Z value for the given Alpha (Type 1 error) = 1.96. Spec: Expected specificity = 0.52(17). Prev: Prevalence of the outcome in the population = 0.04(17). d: Marginal error rate = 0.1. Based on specificity, as per the above-mentioned formula the required sample size would be 100 subjects. However, only 71 patients fulfilled the inclusion criteria and willing to use overnight polysomnography.

**Data collection procedure:** Data collection took all the study participants who had given informed written consent were measured for weight, height, waist circumference, hip circumference, and neck circumference. Modified Mallampati scoring was done with tongue in the mouth to measure pharyngeal crowding because it better represented the tongue position during sleep(11).

**Overnight Polysomnography:** After the completion of questionnaire and measurements, participants who were screened positive with berlin questionnaire willing to undergo overnight polysomnography were sent with type IV polysomnography ApneaLink apparatus, which monitored the airflow and pulse oximetry for the night. Participants were given proper instructions how to connect the apparatus. Minimum of 5 hours of reading in the machine only was taken into consideration. The reading of the polysomnography was taken from the apparatus the next day. Oxygen Desaturation Index (ODI) and Apnea Hypopnea Index (AHI) were noted from the reading and entered into Microsoft Excel sheet against their PPNC and MP scores.

**Statistical analysis:** Data was entered in Microsoft excel spread sheet and analysed with Statistical Program for Social Sciences -IBM SPSS version 22.0. The sensitivity, specificity, positive and negative predictive values and overall diagnostic accuracy of the screening test were calculated against the gold standard. Receiver operating characteristics curve analysis was done. P value < 0.05 will be considered statistically significant.

**Ethical consideration:** The study was approved by Institutional ethical committee. Confidentiality was ensured and informed written consent was obtained from the study participants.

**Table 1: BMI classification according to WHO and Asia-Pacific guidelines(18)**

<table>
<thead>
<tr>
<th>Class</th>
<th>WHO (BMI)</th>
<th>Asia-Pacific (BMI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>&lt;18.5</td>
<td>&lt;18.5</td>
</tr>
<tr>
<td>Normal</td>
<td>18.5–24.9</td>
<td>18.5–22.9</td>
</tr>
<tr>
<td>Overweight</td>
<td>25–29.9</td>
<td>23–24.9</td>
</tr>
<tr>
<td>Obese</td>
<td>≥30</td>
<td>≥25</td>
</tr>
</tbody>
</table>

**Modified Mallampati scoring(19)**

Class I: Soft palate, fauces, pillars, and uvula are visible.
Class II: Soft palate, fauces, and uvula are visible.
Class III: Soft palate and base of uvula are visible.
Class IV: Soft palate is not visible at all.
Results

Table 2. Baseline Characteristics of study participants (n=71)

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Parameters</th>
<th>N(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Age Group</td>
<td></td>
</tr>
<tr>
<td></td>
<td>18-30</td>
<td>37(52.11%)</td>
</tr>
<tr>
<td></td>
<td>31-45</td>
<td>26(36.62%)</td>
</tr>
<tr>
<td></td>
<td>46-60</td>
<td>8(11.27%)</td>
</tr>
<tr>
<td>2</td>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>61(85.92%)</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>10(14.09%)</td>
</tr>
<tr>
<td>3</td>
<td>BMI*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>18.5 - 22.9</td>
<td>15(21.13%)</td>
</tr>
<tr>
<td></td>
<td>23 - 24.9</td>
<td>12(16.9%)</td>
</tr>
<tr>
<td></td>
<td>&gt;25</td>
<td>44(61.97%)</td>
</tr>
<tr>
<td>4</td>
<td>Mallampati Score</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>17(23.94%)</td>
</tr>
</tbody>
</table>
|       | 2            | 29(40.85%)
|       | 3            | 17(23.94%)
|       | 4            | 8(11.27%)  |

*BMI as per Asian population criteria

The study included 86% males and 14% females. Around 17% and 62% belong to overweight and obese category as per Asian BMI classification. Majority (52%) belong to 18-30 years age criteria. (Table 2)

Table 2. Anthropometry of study participants. (n=71)

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Parameters</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BMI</td>
<td>26.2 +/- 3.77</td>
</tr>
<tr>
<td>2</td>
<td>Neck Circumference</td>
<td>37.97 +/- 3.48</td>
</tr>
<tr>
<td>3</td>
<td>PPNC</td>
<td>94.23 +/- 8.17</td>
</tr>
</tbody>
</table>

Prediction of OSA by PPNC: Receiver operating characteristic (ROC) curve analysis was performed for PPNC. Area under the curve was 0.594 (0.46-0.72) i.e. PPNC was able to predict 59.4% (Fig:1) of those who had OSA. Sensitivity of PPNC in prediction of OSA was 70% and specificity 48.78% with a positive predictive value of 50% and negative predictive value of 68.97%.
Prediction of OSA by Modified Mallampati Score: ROC curve was plotted for MMS. AUC for MMS was 0.578 (0.44-0.71). MMS was able to predict 57.8% (Fig:2) Sensitivity of MMS in prediction of OSA was 40% and specificity 75.61% with a positive predictive value of 54.55% and negative predictive value of 63.27%.

Figure 3 ROC curve for Modified Mallampati Scoring and PPNC
Prediction of OSA by Modified Mallampati Score and PPNC together:

ROC analysis was done combining MMS and PPNC to assess the prediction of OSA by these two factors together. AUC for the combined parameters was 0.843 (0.738-0.949), which was good enough. (p value=0.000). Sensitivity of MMS in prediction of OSA was 90% and specificity 77.77% with a positive predictive value of 86.95% and negative predictive value of 84%.

**Discussion:** In our study we have specifically focused on the neck related circumference and indicator of oropharyngeal crowding i.e. Mallampati score. Even though lot of studies have been done on craniofacial anthropometry and obstructive sleep apnea, in our knowledge, nobody has focused solely on PPNC and Mallampati score together. The imbalance between the anatomical and soft tissue structures inside the mouth, especially the tongue could be the causative factor behind the development of OSA. Association of higher Mallampati scoring with OSA with an OR of 3.78 was calculated in a study from Bengaluru(20). A study from Iran shows that the Mallampati score of >2 is associated with increased OSA severity(21). In our study even though the MMS was able to predict only 57.8% of the cases accurately, many of similar studies were able to predict better with a better sample size. Another correlation was found in a study about the association between the fat deposition in the tongue with OSA severity(22). Oropharyngeal crowding with more soft palate length which indicates higher Mallampati score was significantly increased in patients with OSA(23).One of the study done with neck circumference and other anthropometric measurements did not show any correlation with OSA with univariate logistic regression(24). Los Angeles study proves that waist and neck circumferences correlate better than BMI with disease severity in OSA (25). Similar study done in Chile found the significant association of larger neck circumference in patients with OSA which was referred from specialities other than ENT (26). Neck circumference has been portrayed as one of the best indicators of mild to moderate OSA in males (27). Mallampati scoring and neck circumference have been found to be associated with difficult intubation in patients with OSA (28). Patients with mild OSA, neck circumference showed 100% specificity in a study from USA (29). Neck circumference normally increases with height and PPNC is used as a correction for this parameter. PPNC has an association with OSA according to Davies and Stradling(12). Even though not much research was done on the same line, none of the studies proved any strong association of PPNC and OSA. In our study, AUC for PPNC was found to be 0.594 which was better than Mallampati score. Since PPNC takes into account height also it could be a better predictor. But the sensitivity was only 70% and positive predictive value was 50% which brands it as a poor predictor for OSA. So, we did the ROC for PPNC and MMS together, and the results were promising. AUC was found to be 84.3% with a sensitivity of 90%. Research done in this field is still sparse. But in the resource limited setting like India this simple assessment tool seems to diagnose the...
hidden OSA cases. Maybe in future, similar studies with the same parameters in a larger sample size from general Indian population can give a better outcome.

**Conclusion:** PPNC and MMS are fair predictors of OSA. PPNC could be considered a better predictor than neck grip/circumference. Though individually these two parameters have fair predictive ability, combined together, the predictive ability is much higher. These two could be used as a tool in the assessment of study participants with OSA, especially in those whom OPS could not be conducted. There is a need of a robust set of parameters which could predict OSA that could replace invasive and cumbersome assessment procedures for diagnosis.

**References**


